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Responses of Herbage and Browse Production to Six Range Management Strategies

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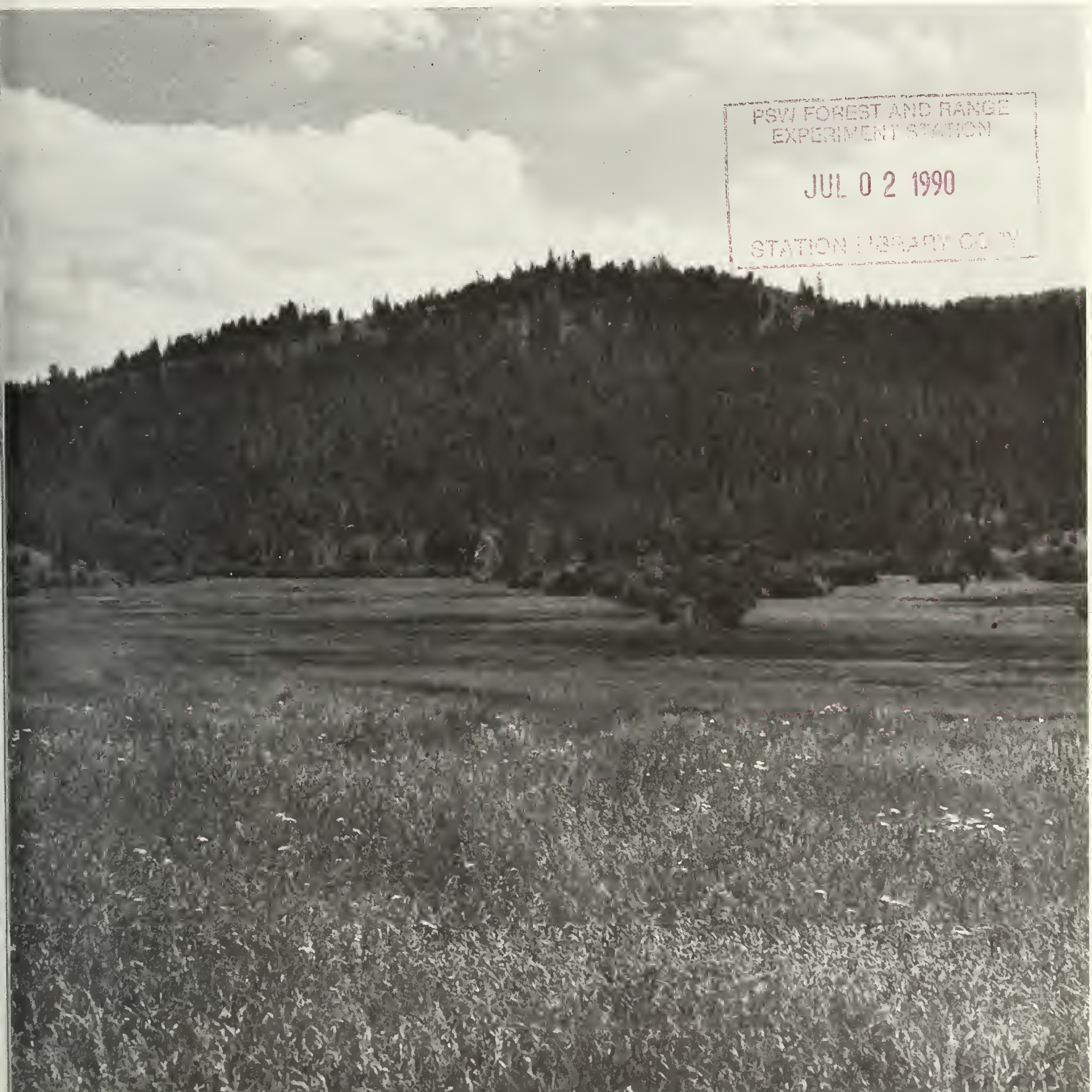

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Abstract

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From 1977 through 1986, herbage and browse production was sampled on 619 sites representing 10 ecosystems and 51 resource units on the Oregon Range Evaluation study area. We determined the effects of six range management strategies and cultural treatments on combined herbage and browse production. Mean herbage and browse production on the forest ecosystems was 145 kilograms per hectare and ranged from 53 to 194 kilograms per hectare. On the range ecosystems, production averaged 417 kilograms per hectare and ranged from 224 to 1037 kilograms per hectare. Production for strategies among forest ecosystems ranged from 59 to 272 kilograms per hectare, and among the range ecosystems it ranged from 337 to 636 kilograms per hectare. Cultural practices increased production on all sites except one, and the increases were significant (p = 0.2) in 8 out of 17 cases.

Keywords: Oregon Range Evaluation Project, cultural practices, biomass.

Summary

The Oregon Range Evaluation Project was established in 1976 to evaluate the impact of grazing management strategies on herbage and browse production, water quantity and quality, and economic resources. Management strategies were applied on 21 private ranches and associated grazing allotments in the central part of eastern Oregon. Elevations range from 600 meters to 2400 meters. The lower elevations are primarily grasslands with a mixture of sagebrush and juniper; the upper elevations are forested with some mountain meadows.

Herbage and browse production was sampled from 1977 through 1986 on 619 sites representing 10 ecosystems and 51 resource units to determine the effects of six range management strategies and cultural treatments. Production data were normalized to a long-term average crop-year production level and transformed for analyses.

Mean herbage and browse production on the forest ecosystems was 145 kilograms per hectare; on the range ecosystems production averaged 417 kilograms per hectare. Production for strategies among forest ecosystems ranged from 59 to 272 kilograms per hectare; among the range ecosystems, it ranged from 337 to 636 kilograms per hectare. Cultural practices increased production on all sites except one, and the increases were significant (p = 0.2) in 8 out of 17 cases. Because herbage production was sampled within 1 or 2 years after the cultural practices were established, we expect production to increase.

Based on our experience, we believe that resource units are not a suitable basic sampling unit; that wood fiber production is not a good indicator of potential herbage and browse production; and that the ecological climax is not a satisfactory criterion to judge the condition of plant communities for sound range management decisions.

Introduction

The Oregon Range Evaluation Project (EVAL) was established in 1976 to evaluate the impact of grazing management strategies on herbage and browse production, water quantity and quality, and economic resources (Sanderson and others 1988). Herbage and browse production data and responses to grazing management strategies and treatments were needed to determine costs and benefits of various management strategies applied on public and private land. The objectives of this study were to determine combined effects of ecosystems and management strategies on herbage and browse production. In addition, we gathered information on the effect of cultural practices on herbage production.

Study Area

EVAL was located in the northern half of Grant County in the central part of eastern Oregon. Study sites were also located in the southeastern and southwestern corners of Grant County. The area is mostly range and forest land within the John Day River system (Sanderson and others 1988). Elevations range from 600 meters to 2400 meters. The lower elevations are primarily grasslands with a mixture of sagebrush (*Artemisia* L. spp.) and juniper (*Juniperus occidentalis* Hook.) and receive about 25 centimeters of precipitation annually. The upper elevations are forested with some mountain meadows and receive about 100 centimeters of precipitation annually.

Rangeland ecosystems were represented by mountain grassland, mountain meadow, sagebrush, juniper, and alpine ecosystems. The alpine ecosystem is probably better described as subalpine, however. The forest ecosystems included Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco), ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.), fir-spruce (*Abies* Mill. spp.-*Picea engelmannii* Parry ex Engelm.), larch (*Larix occidentalis* Nutt.), and lodgepole pine (*Pinus contorta* Dougl. ex Lord.) (Garrison and others 1977).

The EVAL project included 21 private ranches and, when present, associated public grazing allotments on USDA Forest Service or Bureau of Land Management lands. A few additional study areas were located on public lands where grazing by livestock was excluded, including the John Day Fossil Beds National Monument.

Methods

Six management strategies were applied that ranged from environmental management without livestock (strategy A) through environmental management with commodity production maximized (strategy E) and included a category to indicate environmental degradation (strategy X) (table 1). Management strategies were applied to pastures, and herbage and browse production was evaluated for the resource units occurring in each pasture. The term “resource unit” was a generalized description of the vegetation that included the ecosystem, productivity class, and condition class (Forest-Range Task Force 1972) (fig. 1). Resource units were determined from vegetation maps prepared by the Forest Service and Soil Conservation Service using vegetation descriptions unique to the respective Agency. The National Forest System used plant community descriptions by Hall (1973), and the Soil Conservation Service used range sites by Anderson (n.d) to map private land. With these descriptions, we classified the mapped vegetation according to ecosystem, productivity class, and condition class. There were 10 ecosystems in the Oregon EVAL Project area as described by the Forest-Range Task Force (1972).

Table 1—Range management strategies applied by the Oregon Range Evaluation project

Strategy	Definition
A	Environmental management without livestock (no livestock grazing)
B	Environmental management with livestock (livestock present; no attempt made for proper distribution)
C	Extensive management of range environment and livestock (livestock are distributed by such practices as fences, water developments, and stock trails)
D	Intensive management of environment and livestock (distribute livestock and maximize forage production by such cultural practices as seeding, brush control, and irrigation)
E	Maximize commodity production and maintain the base resources with no multiple use considerations—applied only on private land (ranch income maximized from all resources)
X	Resource degradation is occurring; not a management goal

Forest resource units:
Ecosystems: Douglas-fir, ponderosa pine, fir-spruce, larch, and lodgepole pine.

Productivity classes	$m^3 \cdot ha^{-1} \cdot yr^{-1}$
High	8.4+
Moderately high	4.1-8.3
Moderately low	3.5-4.0
Low	0-3.4

Condition classes: Nonstocked; seeding, saplings, and poles less than 28 cm d.b.h.; and trees greater than 28 cm d.b.h.
Range resource units:

Productivity classes	Ecosystems: Juniper	Alpine	Sagebrush	Mountain grassland	Mountain meadow
			$kg^{-1} \cdot ha^{-1} \cdot yr^{-1}$		
High	673-897	1009-1346	1682-3365	2524-3365	3365-4486
Moderately high	449-672	673-1008	1122-1681	1682-2523	2243-3364
Moderately low	224-448	336-672	561-1121	841-1681	1122-2242
Low	0-223	0-335	0-560	0-840	0-1121

Condition classes: Good, fair, and poor. Based on soil and vegetation factors.

Figure 1—Description of forest and range resource units used in the Oregon Range Evaluation Project.

Forest ecosystem productivity and condition were expressed as production of wood fiber and timber stand-size class. Wood fiber production was obtained from Hall (1973), and condition and stand size were classified during the field mapping. For the range ecosystems, both Hall (1973) and Anderson (n.d.) provided mean production information that was used to assign one of four productivity classes. Condition classes for the range ecosystems were based on vegetation cover, composition, vigor, and soil factors and were assigned when study sites were mapped. The condition classification was based on an ecological climax criteria, which, we recognize, does not satisfactorily apply to introduced vegetation commonly used to increase forage production on rangelands.

Available resource units were located on the map and sampled. The minimum sample unit was 16 hectares for all resource units, except for the mountain meadow ecosystem, which had a 4-hectare minimum. The sample unit could occur as a single area or it could be the sum of several areas, provided it was all within the same pasture and the sum met the minimum sample criteria. From pasture maps of resource units, five clusters of four circular plots, 1 square meter in area, were randomly located in each resource unit. The cluster centers were located on the ground, verified, and marked with 1.5-meter steel fence posts or wooden stakes, or both, so they could be relocated. Four plots were 20 meters from the cluster center in each quarter. The compass bearing was rotated such that the same physical plot would not be sampled more than once during the study. The sampling procedure involved clipping all herbage to 2 centimeters above the ground surface at peak of production (after the seed heads were formed and before seed dispersal). Either herbage was sampled before grazing occurred or the plots were protected from grazing by wire cages until sampling occurred. All clipped herbage was sorted by grasses and grass-likes and by forbs and were weighed. The current production of browse species in the first 2 meters above the plot was also sampled. All clipped material was oven-dried and weighed to the nearest 1 gram.

Our intention was to replicate resource units four times, but we found this was not adequate. Therefore our goal was to provide as much information on as many sites as possible. We realized this was an immense task because of the size of the area, both total area and size of resource units within pastures. Selecting resource units by availability and distribution was made more complex by the need to sample each strategy level.

To compare the cultural practices, we used only the grass component of the production data because it was the most important forage component present. Cultural practices were sampled regardless of their success. On some of the less successful sites, forbs were the dominant vegetation, which could have made these sites appear to have higher production than was appropriate. The browse component was excluded for the same reason. All cultural practices were sampled the second year after treatment, except the fertilized areas, which have an important first-year response.

Production data were normalized to an average herbage production year by using equations developed to predict herbage production based on the deviation of the current crop-year (September-June) precipitation from the long-term average (Sneva and Britton 1983). The study area was bounded by five National Oceanic and Atmospheric Administration cooperative weather stations and one station near the center of the study area that provided precipitation records in excess of 20 years, which we refer to as macro stations. We established 14 additional micro weather stations throughout the study area.

Analysis of crop-year precipitation data from the macro stations determined there was a reasonable degree of spatial continuity in storm systems within the study area from September 1 to June 30. Quantitatively, the crop-year precipitation recorded at the four lower elevation stations was similar, whereas the two higher elevation stations had considerably higher precipitation.

The precipitation index (PI) for the macro stations was obtained by dividing the crop-year precipitation by the respective long-term mean (LTM) and is expressed as a percentage. The yield index (YI) was determined by the regression formula, $Y = -23 + 1.23X$, where Y = YI and X= PI (Sneva and Britton 1983). An additional computation was required to determine the PI for the micro stations, because they did not have an established LTM. An estimated LTM was calculated by using the PI of the representative macro station, which was determined by overlaying a map of the micro stations with a Theissen grid (Theissen 1911) of the macro stations as modified by Senva and Calvin (1978) (fig. 2). A second Theissen grid was determined by using all the weather stations with the sample areas assigned to the appropriate polygon to adjust the sample yields to a standard based on the respective LTM

The data were skewed because of numerous zero values from plots that occurred on bare ground and few relatively large values. To account for zero values in the analyses, a value of 1 was added to all data. A log base 10 transformation was used to normalize the data before proceeding with an analysis of variance (ANOVA) and subsequent mean separation procedures. Because productivity classes were based on different production components for the forest and range ecosystems, wood fiber and herbage and browse, respectively, we did a separate analysis for ecosystem groups. Main effects in the ANOVA were strategy and ecosystem.

We were interested primarily in the effect of strategy within each ecosystem; therefore, each individual ecosystem was analyzed separately with strategy as the main effect. The means presented are geometric means; that is, the means of the log-transformed data converted into actual production data. Because of the amount of variation in the type of vegetation we sampled, the 20-percent level was used to test the null hypothesis for the analysis of variance. The 5-percent level was used for mean separations to provide a more conservative test of differences among ecosystems, strategies, and resource units.

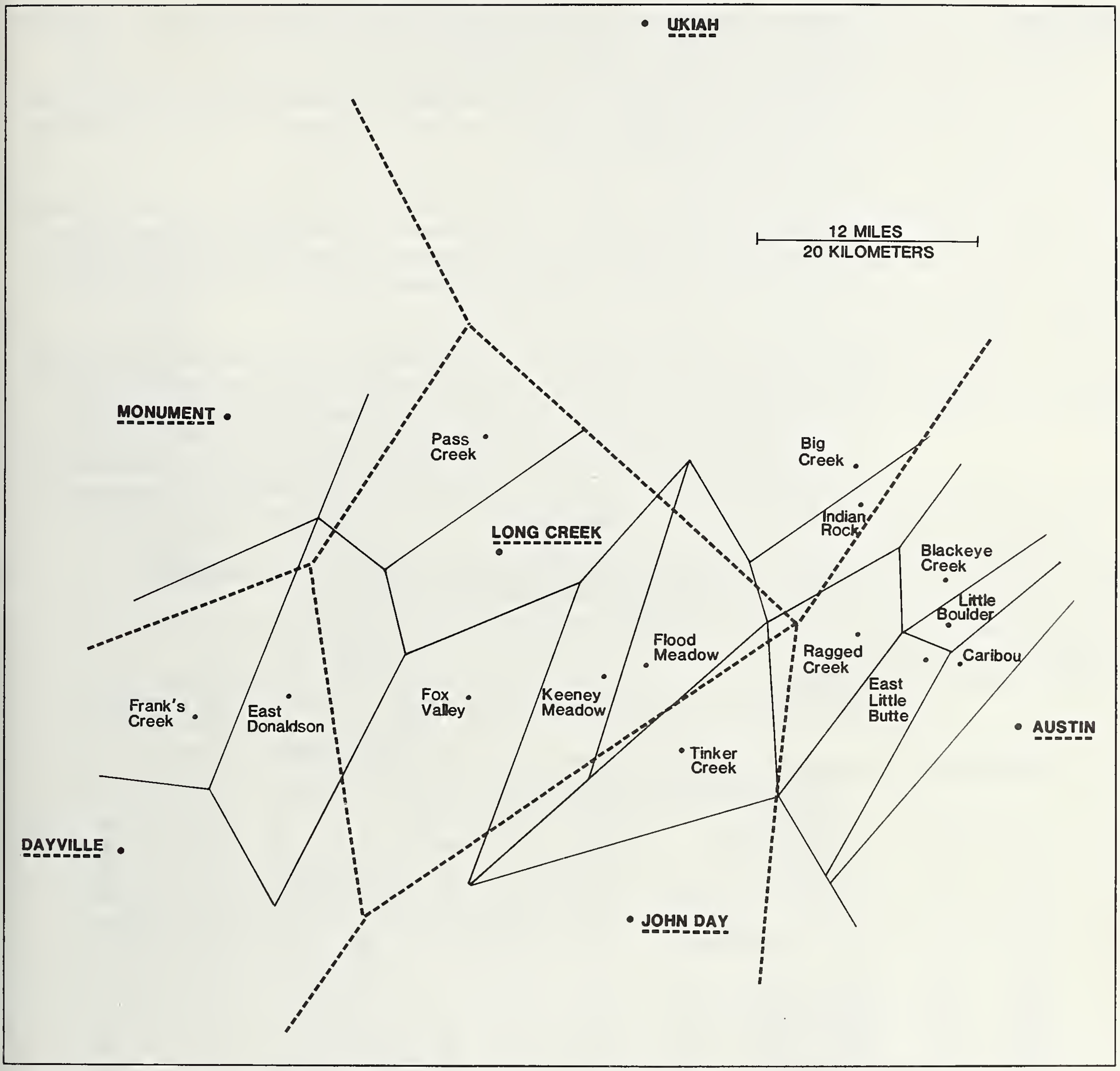

Figure 2—Micro stations were assigned to respective macro station by overlaying a Theissen grid of macro stations (dotted lines). A Theissen grid of all weather stations (solid lines) was used to adjust production data.

Results and Discussion

From 1977 through 1984, we sampled 619 sites—243 in forest ecosystems and 376 in range ecosystems. This represented 51 resource units. Some resource units in the lodgepole pine, fir-spruce, and alpine ecosystems were poorly represented in the study area. Strategies were also unequally represented, with the majority of the samples in the strategies B and C (table 2). This disparity in sample distribution has weakened the statistical analyses.

We have included the sample size associated with each herbage and browse production statistic. In many cases, the differences were not significant because the small sample did not adequately define the variance. There are some valid trends, however, that provide useful management information, but we caution that some results are based on relatively few sample points.

Most of the range and forest sites we sampled were on the lower end of the productivity scale for both wood fiber and herbage and browse. Where more productive soils occurred at the lower elevations, they were generally used to produce hay or grain crops and to feed livestock. Some of these sites, however, were abandoned croplands invaded by sagebrush or juniper, which resulted in a few unusually high levels of production. At the higher elevations, only the mountain meadow and larch ecosystems had any sites in the high or moderately high productivity classes.

Table 2—Number of sites sampled within ecosystems and strategies on the Oregon Range Evaluation Project, 1977-84

	Strategies						
Ecosystem	X	A	B	C	D	E	Total
			Number of sites				
Forest ecosystems:							
Lodgepole pine	0	0	0	6	3	0	9
Fir-spruce	0	4	6	0	0	0	10
Douglas-fir	2	9	20	22	9	6	68
Larch	0	19	25	24	8	1	77
Ponderosa pine	1	8	31	21	11	7	79
Subtotal	3	40	82	73	31	14	243
Range ecosystems:							
Alpine	0	8	10	0	0	0	18
Mountain meadow	1	4	16	23	14	17	75
Sagebrush	7	1	12	26	20	17	83
Mountain grassland	1	0	24	36	10	24	95
Juniper	15	0	23	30	28	9	105
Subtotal	24	13	85	115	72	67	376
Total	27	53	167	188	103	81	619

Forest Ecosystems

Mean herbage and browse production in the forest ecosystems was 145 kilograms per hectare and ranged from 53 (fir-spruce) to 194 (ponderosa pine) kilograms per hectare. Herbage and browse production for ecosystem and strategy main effects in the ANOVA were significantly different ($p = 0.2$). Mean separation showed some overlap among ecosystems. Herbage and browse production for strategies among all forest ecosystems ranged from 59 to 272 kilograms per hectare and increased as the management intensity increased, beginning with strategy X. Strategies B, C, and D were not significantly different ($p = 0.05$) (table 3). The strategy by ecosystem interaction was not significant, which indicates that all the forest ecosystems responded equally to strategies. Herbage and browse production on the forest ecosystems was about what would be expected under closed canopy conditions (Garrison and others 1977). The differences in herbage and browse production can probably be attributed to the canopy density of the respective ecosystem: spruce-fir has a dense canopy with a sparse understory, whereas ponderosa pine is generally more open. This relation is confounded, however, by the control of fire, which has allowed fir and Douglas-fir seedlings to become an established component in these ecosystems—especially in the moister sites—and has closed the canopy.

Individual ANOVA's of each forest ecosystem showed that the mean herbage and browse production among strategies was significantly different ($p = 0.05$) for only the Douglas-fir and ponderosa pine ecosystems. Although there is a considerable amount of overlap among strategies, strategy E consistently has the highest herbage and browse production (table 4). The lodgepole pine and spruce-fir ecosystems were not well represented in either the number of sample sites, 9 and 10, respectively, or the number of strategies. The larch ecosystem was fairly well represented by strategies, but herbage and browse production was about the same at all strategy levels except strategy E, which was represented by only one sample site.

Table 3—Mean herbage production for forest ecosystems and strategies on the Oregon Range Evaluation Project, 1977-84

Forest ecosystems	Strategies X	A	B	C	D	E	Mean[a]
	Kilograms per hectare						
Fir-spruce	—	53	53	—	—	—	53a
Larch	—	92	113	125	116	224	113b
Douglas-fir	53	152	168	145	160	285	160c
Lodgepole pine	—	—	—	185	128	—	164cd
Ponderosa pine	73	230	194	172	199	265	194d
Means	59a	119b	145c	148c	156c	272d	145

[a] Means having no letter in common are significantly different according to the LSD test ($p = 0.05$).

Table 4—Comparisons of the mean herbage and browse production among strategies within ecosystems on the Oregon Range Evaluation Project, 1977-84

Ecosystems	Strategy[a]					
Forest ecosystems:						
Douglas-fir	X	C	A	D	B	E
Ponderosa pine	X	C	B	D	A	E
Larch	A	B	D	C	E	
Spruce-fir	A	B				
Lodgepole pine	D	C				
Range ecosystems:						
Sagebrush	B	C	A	E	D	X
Mountain meadow	X	A	D	B	C	E
Juniper	C	B	D	X	E	
Mountain grassland	X	B	C	D	E	
Alpine	A	B				

[a] Strategy means with a common underline are not significantly different according to the ANOVA or LSD test (p = 0.05).

It is not surprising that strategy E was the only strategy having a significant effect on herbage and browse production in the forest understory. Strategy E was applied only on pastures on private land, and the forest environment was intensively influenced by range improvements to maximize commodity production. The effects of strategy D on herbage and browse production in the forest ecosystems is not clear, because the range improvements altered only a small portion of forest environment, especially on public lands. In addition, timber harvest and an epidemic bark beetle (*Dendroctonus* spp.) outbreak decreased the overstory, which stimulated an increase in the production of the understory vegetation. On all strategies, we avoided areas where commercial timber harvests had occurred in the past 10 years, but we were unable to avoid the impact of the bark beetle. Herbage and browse productivity classes were only significantly different on the larch ecosystem and were in reversed order (table 5). Studies show that site indices, developed for tree growth, are poor predictors for herbaceous understory vegetation productivity (Basile 1971, Mitchell and Pickens 1985). It is therefore not surprising that herbage and browse production in the forest ecosystems is not related to wood fiber productivity classes. Precommercial thinning

Table 5—Mean herbage and browse production and number of sites sampled within forest ecosystems, productivity classes, and strategies on the Oregon Range Evaluation Project, 1977-84

Ecosystem and productivity class	Strategy X	A	B	C	D	E	Mean[a]
	Kilograms per hectare (number)						
Douglas-fir:							
Moderately low			172 (1)	152 (1)	160 (2)	285 (1)	172 (7)
Low	53 (2)	152 (9)	168 (19)	141 (19)	160 (7)	285 (5)	160 (61)
Ponderosa pine:							
Moderately low			138 (1)	353 (2)			259 (3)
Low	73 (1)	230 (8)	194 (30)	160 (19)	199 (11)	265 (7)	194 (76)
Spruce-fir, low		53 (4)	53 (6)				53 (10)
Larch:							
Moderately high			75 (3)	81 (3)			79a (6)
Moderately low		92 (19)	119 (22)	135 (21)	116 (8)	224 (1)	116b (71)
Lodgepole pine, moderately low				141 (6)	214 (3)		164 (9)

[a]Herbage and browse production means within ecosystem having no letter in common are significantly different according to the LSD test (p = 0.05).

at a 6-meter spacing was the only cultural treatment applied on the forest ecosystems. During this study, precommerical thinning did not significantly increase herbage and browse production except for ponderosa pine with low productivity and within the timber-size condition class (table 6). These herbage and browse production figures take into consideration only the initial understory response to opening the tree canopy. Further, not all the thinned sites were seeded after treatment. In some cases, sufficient herbaceous vegetation was already present, or the site was not sufficiently disturbed to provide an adequate seedbed. Also many of the untreated sites had been "thinned" by the bark beetle!

Table 6—Summary of grass production on forest resource units as a result of precommercial thinning and number of sites sampled on the Oregon Range Evaluation Project, 1977-84

	Grass production	
Resource unit	Treated	Untreated
	Kilograms per hectare (number)	
Douglas-fir,	124	81
low, timber	(2)	(44)
Ponderosa pine,	149	128
low, poles	(5)	(47)
Ponderosa pine,	173	88[a]
low, timber	(2)	(21)

[a]Treatment mean is significantly different from untreated mean according to t-test ($p = 0.2$).

Regardless of whether the thinning released existing understory vegetation or the understory was re-established through seeding, 2 or 3 years after treatment may not be sufficient time to expect a significant response. McConnell and Smith (1965) report significant but relatively low yields in understory vegetation 3 years after ponderosa pine stands are thinned; understory yields tripled 8 years after thinning (McConnell and Smith 1970). On seeded, clearcut lodgepole pine sites, total understory production averaged 520 kilograms per hectare after 2 growing seasons (Basile 1971), and peaked (897 to 1122 kilograms per hectare) after 11 growing seasons (Basile and Jensen 1971).

Besides creating livestock herbage and browse, thinning has other values. Livestock are more accessible in open timber stands, thereby making them easier to gather and move. Open timber stands have more aesthetic appeal than dense, closed stands. Thinned stands also provide an increase in understory forage for deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*), but heavy thinning may reduce hiding and thermal cover for them (Crouch 1986). Finally, there is potential increase in wood fiber production as a result of thinning.

Range Ecosystems

Mean herbage and browse production in the range ecosystems was 417 kilograms per hectare and ranged from 224 (juniper) to 1037 (mountain meadow) kilograms per hectare. Main effects, ecosystem, and strategy in the ANOVA were significantly different ($p = 0.2$). Mean herbage and browse production (LSD) among the range ecosystems was significantly different ($p = 0.05$), except for the alpine and sagebrush ecosystems, which were not significantly different. Although strategy X was the least productive overall (337 kilograms per hectare) and strategy E was the most productive (636 kilograms per hectare), the individual range ecosystems responded differently to management strategies. This response is reflected in a significant strategy by ecosystem interaction (table 7). Unlike the forest ecosystems, management strategies are fairly well represented in all the range ecosystems, except the alpine ecosystem, which has only strategies A and B.

Table 7—Mean herbage and browse production for range ecosystems and strategies on the Oregon Range Evaluation Project, 1977-84

Range ecosystems	Strategies X	C	B	D	A	E	Mean[a]
	Kilograms per hectare						
Juniper	253	145	247	252	—	379	224a
Mountain grassland	148	353	259	362	—	527	362b
Sagebrush	636	345	337	579	417	552	447c
Alpine	—	—	651	—	540	—	607c
Mountain meadow	565	1112	945	881	714	1308	1307d
Means	337a	353a	379ab	427ab	579bc	636c	417

[a]Means having no letter in common are significantly different according to the LSD test ($p = 0.05$).

Individual ANOVA of the range ecosystems indicated significant differences ($p = 0.05$) of herbage and browse production among strategies within the sagebrush, juniper, and mountain grassland ecosystems, but there was considerable overlap (table 4). The mountain grassland ecosystem increased in production as management strategy increased, but the sagebrush and juniper ecosystems responded much differently. Both had relatively high herbage and browse production in strategy X. This probably occurred because the high sagebrush densities resulted in large amounts of browse production.

Productivity classes were significantly different ($p = 0.05$) in the sagebrush, mountain grassland, and mountain meadow ecosystems, but not in the juniper or alpine ecosystems (table 8). Production did not consistently increase in magnitude, however, from the low to high productivity classes. We do not have a reasonable explanation for this capricious response. Herbage and browse production was generally lower than expected, based on the assigned productivity classes. Condition class did not have a significant effect on production on any of the range ecosystems except juniper. In the juniper ecosystem, the sites in good condition produced significantly more herbage and browse than the fair and poor sites, and the fair and poor sites were not significantly different ($p = 0.2$). We expected the sites in better condition to be more productive, but that was not the case. It is our judgment that the condition criteria are inadequate or are not consistently applied. Condition was based on an ecological climax criteria and does not adequately reflect management objectives, primarily because seeded species are mostly introduced grasses. Consequently, seeded areas were classed as "poor" condition regardless of the production of the established vegetation. Changing this concept to reflect management objectives instead of ecological status would remove this bias. Cultural practices, such as removal of juniper or shrubs, seeding, and fertilization, increased grass production on all sites except the mountain meadow, low productivity level poor condition resource unit. Significant increases occurred in 8 out of 17 cases (table 9). For treatments other than fertilization, which was measured the first and second years after treatment, there was a lag in response. As in the forest ecosystems, we measured vegetative herbage response 2 years after treatment for all other treatments. This is still early for seedings and vegetation released by shrub removal to show full potential production.

Table 8—Mean herbage and browse production and number of sites sampled within range ecosystem for production levels and strategies on the Oregon Range Evaluation Project, 1977-84

Ecosystem and Productivity class	Strategy						
	X	A	B	C	D	E	Mean[ab]
	Kilograms per hectare (number)						
Sagebrush:							
High				1339 (1)			1339a (1)
Moderately low	636 (7)		397 (7)	447 (14)	689 (13)	636 (12)	552ab (53)
Moderately high			272 (1)	407 (1)	651 (1)		417cb (3)
Low		417 (1)	259 (4)	204 (10)	370 (6)	388 (5)	285c (26)
Juniper:							
High	285 (13)		224 (5)	552 (1)	299 (15)	247 (3)	278 (37)
Low	75 (1)		235 (7)	102 (6)	241 (4)	480 (4)	204 (22)
Moderately low			265 (2)	141 (8)	247 (4)	397 (1)	194 (15)
Moderately high	209 (1)		265 (9)	152 (15)	164 (5)	540 (1)	190 (31)
Mountain grassland:							
Moderately low			540 (8)	945 (12)	593 (5)	784 (14)	749a (39)
Moderately high				379 (1)			379ab (1)
Low	148 (1)		176 (16)	209 (23)	214 (5)	306 (10)	214b (55)
Mountain meadow:							
Moderately high			2079 (2)	2941 (1)	2334 (2)	902 (1)	1985a (6)
High	565 (1)	515 (1)	784 (3)	1308 (6)	1810 (2)	1504 (12)	1249a (25)
Moderately low		803 (3)	861 (11)	822 (10)	967 (6)	945 (3)	881b (33)
Low				1308 (6)	337 (4)	784 (1)	766b (11)
Alpine:							
Moderately low		540 (8)	651 (10)				607 (18)

[a] Herbage and browse production means within the ecosystem having no letter in common are significantly different according to the LSD test (p = 0.05).
[b] Herbage and browse production means within ecosystem with no letters are not significantly different according to the ANOVA test (p = 0.2).

Table 9—Summary of grass production on range resource units as a result of treatment and number of sites sampled on the Oregon Range Evaluation Project, 1977-84

Resource unit	Range management practice	Grass production Treated	Untreated[a]
		Kilograms per hectare (number)	
Sagebrush:			
Moderately low, fair	Chemical spray	492 (3)	304* (16)
Moderately low, fair	Fire	514 (5)	304* (16)
Low, fair	Fire	185 (2)	68 (10)
Moderately low, poor	Seed	532 (6)	230* (15)
Juniper, high, poor	Mechanical control	290 (4)	171* (12)
Mountain grassland:			
Moderately low, fair	Seed	630 (3)	480 (10)
Moderately low, poor	Seed	970 (3)	754 (12)
Low, poor	Seed	411 (2)	65* (25)
Mountain meadow:			
High, fair	Seed	1684 (2)	862 (6)
High, fair	Fertilize	1450 (4)	826* (6)
High, poor	Fertilize	1356 (2)	731* (10)
Moderately high, fair	Fertilize	2412 (3)	1446 (3)
Moderately low, fair	Fertilize	1016 (3)	555 (8)
Low, poor	Fertilize	61 (2)	482 (4)

[a] Asterisk indicates that the treatment mean is significantly different from untreated mean according to t-test (p = 0.2).

Recommendations

Our goal was to apply sufficient research control to evaluate the application of state-of-the-art range management strategies on over 842,600 hectares of public and private land. Unfortunately, those of us who analyzed and interpreted the data did not design the sampling procedure, because we would have taken a different approach. A task of this magnitude has never been attempted previously and will probably never be attempted again; therefore, we feel this data should be presented for public scrutiny even though it has shortcomings. With this in mind, we offer the following recommendations: the resource unit is best suited to accumulate a wide variety of data under a generalized category for regional or national planning, but it is a poor sampling unit. More useful would have been a sampling of the plant communities as they were described by the Forest Service and the Soil Conservation Service, than aggregating them into resource units for the sample unit. There is no valid reason to use either wood fiber as the production criterion to evaluate understory production or to use tree size class to reflect condition. The tree canopy cover has a valid relation with understory production, however, and should be incorporated in a condition criteria.

We recognize that ecological climax is not a satisfactory criterion to judge the condition of plant communities and recommend a criterion be established that would reflect environmental factors and management objectives.

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From 1977 through 1986, herbage and browse production was sampled on 619 sites representing 10 ecosystems and 51 resource units on the Oregon Range Evaluation study area. We determined the effects of six range management strategies and cultural treatments on combined herbage and browse production. Mean herbage and browse production on the forest ecosystems was 145 kilograms per hectare and ranged from 53 to 194 kilograms per hectare. On the range ecosystems, production averaged 417 kilograms per hectare and ranged from 224 to 1037 kilograms per hectare. Production for strategies among forest ecosystems ranged from 59 to 272 kilograms per hectare, and among the range ecosystems it ranged from 337 to 636 kilograms per hectare. Cultural practices increased production on all sites except one, and the increases were significant ($p = 0.2$) in 8 out of 17 cases.

Keywords: Oregon Range Evaluation Project, cultural practices, biomass.

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